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Causality between Energy and Economic Growth: the Italian case

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Abstract

The causal relationship between economic growth and energy consumption represents a widely studied topic in energy economics literature. Although it is very well known that there is a strong correlation between energy use and growth, the issue of "causality" still remains to be answered. This study aims to investigate the possibility of the "energy-demand-led growth" and "growth-driven energy demand" hypotheses in Italy by testing the causality between real GDP and electric power consumption through an ECM model. Results do not reveal any causality linkage.

Keywords: Causality; Economic growth; Energy Consumption

1. Introduction

The causal relationship between economic growth and energy consumption in a country represents a widely studied topic in energy economics literature. Although it is very well known that there is a strong correlation between energy use and growth, the issue of "causality" – i.e. which of the two variables takes *precedence* over the other and, therefore, if economic growth determines a major energy consumption or vice-versa - remains still to be answered (Sari et al. [26]; Konya [15], [16]; Masih and Masih [21])

Recently, this question has faced a renewed interest given the growing debate about the world climate changes as a consequence of greenhouse gases emissions. The direction of causality, in fact, can help the policy makers to take the most appropriate decisions in climatic matters: for example, evidence of unidirectional causality running from income to energy consumption could suggest the full compatibility between energy conservation policies and economic growth policies since the firsts can be pursued without limiting the seconds. On the opposite the finding of unidirectional causality running from energy consumption to income may assume a particular significance with regard to the current debate about whether developing countries should be allowed to pollute more than the industrialized world, arguing that energy consumption could represent a *stimulus* for economic growth in LDCs (Guttormsen [13]).

Since the pioneering work of Kraft and Kraft [17], the large amount of works in this matter has found evidence of bi-directional, uni-directional or no causality according to the country analyzed. Moreover, in some countries, different findings occur for different time periods, leading to no certain conclusion. With only regard to the most recent empirical contributions[1], evidence of bi-directional relationship is found in the works of Ghali and El-Sakka [07] and Jumbe [14] which have analyzed Canada and Malawi respectively. On the opposite, the studies of Wolde-Rufael [32] and Morimoto and Hope [22] in Shangai and Sri-Lanka show the presence of uni-directional causality running from energy consumption to economic growth. The results of Soytas and Sary [28] are once more mixed: their empirical analysis of G-7 countries and some emerging markets over different time period suggest the existence of bi-directional causality in Argentina, uni-directional causality from GDP to energy consumption in Italy and Korea, and uni-directional causality from energy consumption to GDP in Turkey, France, West Germany and Japan. In the end, the work of Oh and Lee [25] in Korea finds evidence of a long-run bi-directional causal relationship and a short-run unidirectional causality running from energy to GDP.

With the exclusion of the obvious differences among countries in terms of structural and economic policy characteristics, the multiplicity of results obtained depend upon the variables adopted and, above all, from the methodological approach followed to test causality. Initially the causal relationship was tested by using the standard Granger [09] test and the Sims' [27] methodology. These two approaches assume that data series are stationary. As pointed out by Granger [10], [11], these tests do not permit to find any long-run information between the variables, being able to capture only the short-run relationships. For this reason, the empirical findings of causal linkages based on these tests are often inconsistent. Later, researchers have begun to employ a cointegration approach which is now considered as the most appropriate to investigate for causality since overcomes the problems depicted before.

[1]For a complete overview of empirical studies on the causality between energy consumption and economic growth see Guttormsen [13] and Mozumder and Marathe [23].

The aim of the current study is to investigate the possibility of the "energy-demand-led growth" and "growth-driven energy demand" hypotheses in Italy by testing the causality between real GDP and electric power consumption through an Error Correction Model (ECM). Italy represents an interesting case of study given the distinctive aspects which characterize its national energy sector with respect to that of other European countries, as will be deeply illustrated in the present work.

The reminder of this study is organized as follows. Section 2 illustrates the distinctive characteristics of the Italian energy sector. Section 3 reports the empirical application. This part is composed of four sub-sections: the first discusses briefly the econometric strategy adopted; the second describes the data utilized and the properties of the time series; the third and the fourth report, respectively, the results obtained from cointegration and causality tests. Finally, section 4 ends with some concluding remarks.

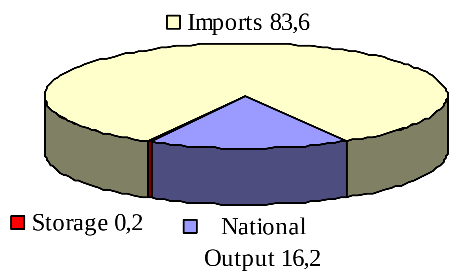
2. Energy Sector in Italy

The energy situation in Italy represents a very interesting case of study for several orders of reason.

First of all, Italy is one of the least energy intensive countries in the world. This result is mainly due to the high level of taxation which characterizes the Italian energy market. Taxes, in fact, represent a key-element of Italy's energy policy since are often employed to promote energy efficiency and, thus, to reduce energy imports and energy-related pollution (Evans [06]).

Second, Italy has few natural resources, lacking of large deposits of coal or oil. The country's most important mineral resources are only the Po Valley and the offshore Adriatic. In addition, national output is declining in recent years because of the lack of cost-effectiveness in the extraction of Italian gas. For these reasons, Italy imports increasingly high percentages of its total energy consumed. Graph 2.1 shows that in 2004 Italy's natural gas imports accounted for over 83 percent of total consumption.

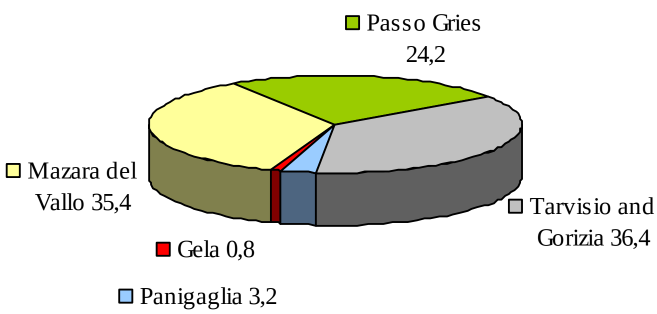
Graph 2.1. Italy's Natural Gas Injections in 2004 (percent of total)



Source: own elaboration on figures from "Authority of Electricity and Gas" (AEEG) [02]

With regard to the countries supplying energy to Italy, oil and natural gas imports come from Russia, Algeria, Libya, and various countries in the Middle East. On the opposite, coal imports come, for the most part, from the U.S., Australia and South Africa. Graph 2.2 reports the percentages of natural gas imported in 2004 by point of arrival. The highest share of imports (36,4%) has arrived through Tarvisio and Gorizia, where most of the incoming natural gas comes from the former Soviet Union. Next in importance is the gas originating in Algeria (38.6% of total imports), incoming through Mazara del Vallo, in Sicily, and Panignaglia, in Liguria. Through Passo Gries in the North has entered a share of 24.2% of gas produced in Netherlands, Norwey and other EU countries. Finally, the remaining percentage of imported gas has arrived from Libya, coming to Italy through Gela (0.8%).

Graph 2.2. Italy's Natural Gas Imports in 2003 by point of arrival (percent of total)



Source: own elaboration on figures from "Authority of Electricity and Gas" (AEEG) [02]

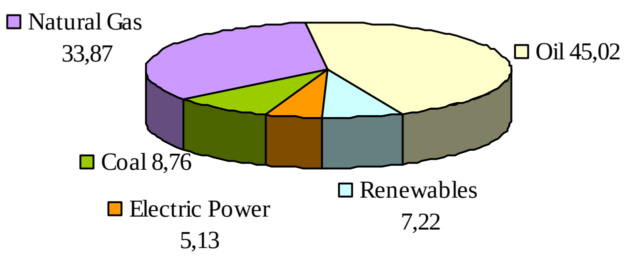
Third, most of the Italian energy consumption derives from oil. Natural gas accounts for another large share of energy use while coal, hydro and renewables provide for most of the rest. With particular regard to the electricity power generation, most electricity is generated with oil and natural gas, even if renewables have become an increasing source of power. Table 2.1 and graph 2.3 show, respectively, Italy's energy consumption in 2004 in absolute and percent values, by source.

Table 2.1. Italy's energy consumption in 2004 by source (absolute values in Mtep).

		Coal	Natural Gas	Oil	Renewables	Electric Power	TOTAL
1	**National Output**	0.4	10.7	5.4	13.5	0.0	30.0
2	**Imports**	17.1	55.5	107.6	0.6	10.2	191.0
3	**Exports**	0.1	0.1	24.7	0.0	0.2	25.1
4	**Stocks**	0.3	-0.1	0.3	0.0	0.0	0.5
5	**Consumption availability (1+2-3-4)**	**17.1**	**66.2**	**88.0**	**14.1**	**10.0**	**195.5**

Source: own elaboration on data from Authority of Electricity and Gas" (AEEG) [02]

Graph 2.3. Italy's energy consumption in 2004 by source (percent of total)



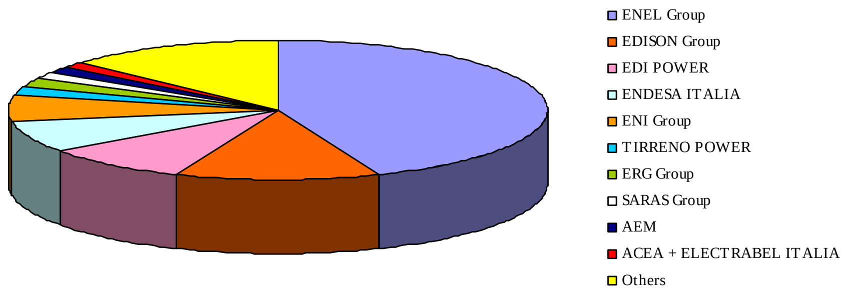
Source: own elaboration on data from "Authority of Electricity and Gas" (AEEG) [02]

Fourth, nowadays Italy does not produce nuclear energy. As a consequence of the referendum in 1987, all operating nuclear power plants on the territory were closed down. Prior to the ban, 3.8% of Italy's domestic power was nuclear and Italy had 1.15 GW of nuclear capacity (Evans [06]).

Finally, the level of competition in Italy's energy industry was quite restricted until the early 1990s: the most of Italy's energy sector was exclusively in the hands of state corporations (as the state electricity company - *ENEL* - and the state hydrocarbon company - *ENI* -). From the 1990s Italy has begun a process of deregulation which has involved its internal energy sector: the state companies were widely privatized and, following an "unbundling" strategy, other companies (such as the municipal ones) could enter the generation and distribution of energy market. Furthermore, an independent agency (the "Authority of Electricity and Gas" – *AEEG*) was established in 1995 with the twice aim of regulating the electricity and the gas sectors and carrying on a consultative and support activity[2]. In the electricity sector a state-owned company (Transmission System Operator – *TSO*) was created at the beginning of 2000 with responsibility for all activities related to electricity transmission. Graph 2.4 shows Italy's natural gas market in 2004 by companies, arranged in percent values.

[2]The establishment of the AAEG represents a crucial step towards the complete liberalization of the internal energy market. This agency, in fact, should ensure the so-called "Third Party Accessibility" – TPA, guaranteeing for the firms' free access to the energy market.

Graph 2.4. Italy's natural gas market in 2004 by companies (percent of total)



Source: own elaboration on data from "Authority of Electricity and Gas" (AEEG) [02]

For all these reasons, the Italian energy market is expected to experience significant changes in the next years. Specifically, the electricity prices - which are among the highest in Europe - are expected to reduce as a consequence of the influx of new companies and, generally, of the increased level of competition in the energy sector. In this sense, the adoption of the EU Regulation (EC) 1228/2003 (concerning the conditions for network access for cross-border exchanges in electricity) and, above all, EU directive 2003/54/EC (concerning the complete liberalization of the non-civil electricity market by 1 July 2007) should lead great benefits to the citizens in terms of a decreased energy price (GRNT [12]). But the real challenge for the future is represented by the so-called "energy transition" - i.e. investments in cleaner technologies to replace and expand the depreciating capital stock and meet growing energy demand (Lise and Van Montfort [18]). The implementation of green energy-policies could permit not only to move towards sustainable development in a globalized world, but also to reduce the excessive dependence from energy imports.

3. Econometric methodology, data used and results obtained

In order to examine the relationship between energy consumption and economic growth in Italy, a two-step procedure is adopted. The first step investigates the existence of a long-run relationship between the variables through a cointegration analysis. The second step explores the causal relationship between the series. If the series are non-stationary and the linear combination of them is non-stationary, then standard Granger's causality test should be employed. But, if the series are non-stationary and the linear combination of them is stationary, ECM approach should be adopted (Yang [33]). For this reason, testing for cointegration is a necessary prerequisite to implement the causality test (Stern [29])

The articulation of the present section follows this two-step technique. After a brief description of data employed, it illustrates the properties of time series. The order of integration of each variable is established first through a visual analysis and then implementing unit root tests[3]. Then are reported the results for cointegration and causality tests.

[3]It is sometimes argued that pre-test the variables for their order of integration maybe superfluous since what is important is whether a combination of variables is cointegrated or not. Anyway, in this study series were pre-tested since, as pointed out by Stock and Watson [31], causality tests are very sensitive to the stationarity of the series. Moreover, the inclusion of variables with different orders of integration can lead to an "unbalanced" long-run regression.

Data used

All data utilized in this study come from the "*World Developed Indicators*" (*WDI*) elaborated by the World Bank. More precisely, the dataset comprise annual measures of GDP per capita in 1995 $US million (*GDP*) and of electric power consumption in kwh per capita (*EPC*) over the sample period 1960-2001[4]. Both the series have been transformed in natural logarithms and the resulting variables are respectively denoted as $\ln(GDP)$ and $\ln(EPC)$. Table A.1 in appendix shows the descriptive statistics of these two series.

Unit root tests

Since many macroeconomic series are non stationary (Nelson and Plosser [24]), unit root tests are useful to determine the order of integration of the variables and, therefore, to provide the time-series properties of data. Nevertheless, we can get interesting information plotting the series and the correlograms of the variables in both levels and first differences.
Graph A.1 in appendix highlights how the natural logarithm of *GDP* and *EPC* has constantly increased over the period 1960-2001. On the opposite, the series in first differences seem to be stationary over time. This could mean that the two variables become stationary if differenced once. In other words, the graphical analysis should suggest the conclusion that $\ln(GDP)$ and $\ln(EPC)$ are ~ I(1). Obviously, this is only a

[4]GDP was preferred to GNP since energy consumption should be related to goods and services domestically produced in a country.

provisional analysis: without implementing unit root tests no definitive conclusion can be drawn. Nevertheless, it's interesting to note how the series – both in level and first differences - seem substantially to move together. This is clearly evident when $\ln(GDP)$ and $\ln(EPC)$ are represented in level but is even more marked looking at the series in first difference: with the exception of the first five years (1960-1965), the graph of each series seems to be superimposed (in this sense, the negative peak of 1975, surely due to the consequences of the 1973 oil shock, is particularly suggestive).

Graph A.2 in appendix reports the autocorrelation function for the series in level and in first differences. It seems to suggest a slow decay rate in the autocorrelation function for the variables in level as well as a more rapid decay rate for the variables in first difference. This could mean that the shocks do not persist over time only when the variables are differenced. In other words, the levels could follow random walks. Again, this is only a tentative to draw some conclusion from a visual analysis.

In order to implement a more rigorous test to verify the presence of a unit root in the series, an Augmented Dickey-Fuller (ADF) test was employed. This test represents a wider version of the standard Dickey-Fuller (DF) test [03],[04].

Given a simple AR(1) process:

$$y_t = \rho y_{t-1} + x_t'\delta + e_t \qquad [3.1]$$

where y_t is a time series (in this case, $\ln(GDP)$ and $\ln(EPC)$), x_t represents optional exogenous regressors (e.g. a constant or a constant and a trend), ρ and δ are parameter to be estimated and e_t is a white noise error component, the standard DF is implemented through the Ordinary Least Squares (OLS) estimation of model [3.1] after subtracting the term y_{t-1} from both sides of the equation:

$$\Delta y_t = \alpha y_{t-1} + x'\delta + e_t \qquad [3.2]$$

where Δ is the first difference operator, $\alpha = \rho - 1$, and e_t is the error term with zero mean and constant variance. Now, adopting a simple t-test, if $\alpha = 0$ (i.e. if $\rho = 1$), then y is a nonstationary series and its variance increases with time. Under such cases, the series is said to be I(1), requiring to be differenced once to achieve stationarity[5].

Nevertheless, if the series is correlated at higher order lags, the assumption of white noise error is violated. In such circumstance, the ADF test represents a possible solution to this problem: it permits to correct for higher order correlation employing lagged differences of the series y_t among the regressors. In other words, the ADF test "augments" the traditional DF test assuming that the y series is an AR(p) process and, therefore, adding p lagged difference terms of the dependent variable to the right hand side of regression [3.2]:

$$\Delta y_t = \alpha y_{t-1} + x'\delta + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \upsilon_t \qquad [3.3]$$

[5]The distribution of the t-test is non-standard since it assumes the stationarity of the data while under the null hypothesis of a unit root the data generating the process is non-stationary. To overcome this problem Dickey and Fuller [03] first and MacKinnon [19], [20] later, have tabulated special critical values for the Student's t-distribution for various test and simple sizes to be used in these cases.

In the present study an ADF test was performed to $\ln(GDP)$ and $\ln(EPC)$ series. In both the cases, a constant and a linear trend were included since this represents the most general specification. The max number of lags was set equal to 9, which should represent a sufficiently high number to remove serial correlation in the residuals. Finally, the choice of the number of lags actually employed was assigned to the Akaike Information Criterion (AIC) [01]. Table 3.1 reports the results obtained.

Table 3.1. ADF Unit-roots tests for stationarity.

Variables	Level	First-difference
$\ln(GDP)$	-2.130547 (0.5141)	-6.009879 (0.0001)
$\ln(EPC)$	-3.182022 (0.1022)	-5.752301 (0.0001)

Notes:
Lag Length: 0, automatic based on AIC [01].
In brackets MacKinnon [20] one-sided p-values.
Unit root tests were performed using E-Views 5 econometric software package.

According to the AIC, the number of lags used is equal to zero, meaning that the standard DF test is in this case to be preferred to the ADF test. Results suggest that the null hypothesis that the two series contain a unit root cannot be rejected, while the null hypothesis that the series in first difference contain a unit root can be rejected. Summarizing, both $\ln(GDP)$ and $\ln(EPC)$ are I(1) and this confirms the superficial impression obtained looking at the graphs.

Cointegration test

In order to test for causality between the series $\ln(GDP)$ and $\ln(EPC)$ through the ECM, it's necessary to verify if the two series are cointegrated.

Generally speaking, two or more variables are said to be cointegrated if they share a common trend. In other words, the series are linked by some long-run equilibrium relationship from which they can deviate in the short-run but they must return to in the long-run, i.e. they exhibit the same stochastic trend (Stock and Watson [30]). Cointegration can be considered as an exception to the general rule which establishes that, if two series are both I(1), then any linear combination of them will yield a series which is also I(1). The exception is when a linear combination of two or more series is integrated of a lower order: in this case, in fact, the common stochastic trend is cancelled out, leading to something that is not spurious but that has some significance in economic terms.

The existence of a cointegration relationship between the series $\ln(GDP)$ and $\ln(EPC)$ was verified implementing a unit root ADF test on the residuals from the following two long-run regressions between the levels variables, estimated through the OLS method [6]:

$$\ln(GDP)_t = a_o + a_1 \ln(ECP)_t + \mu_t \qquad [3.4]$$

$$\ln(ECP)_t = b_0 + b_1 \ln(GDP)_t + \eta_t \qquad [3.5]$$

[6] Regressions [3.4] and [3.5] are defined as "cointegration equations".

As before, in both the cases the max number of lags to be used was set equal to 9 and the choice of the number of lags actually employed was assigned to the Akaike's final prediction error criterion [01].
Table 3.2 reports the results obtained from the cointegration tests.

Table 3.2. Cointegration tests

Regression	ADF
$\ln(GDP)$ on $\ln(EPC)$	-2.020811 (0.0427)
$\ln(EPC)$ on $\ln(GDP)$	-2.091907 (0.0364)

Notes:
Lag Length: 0, automatic based on AIC [01].
Regressions do not include exogenous variables (intercept or time trend).
In brackets MacKinnon [20] one-sided p-values.
Unit root tests were performed using E-Views 5 econometric software package.

Again, the AIC criterion favours the DF over the ADF test. The standard DF unit root test suggests that the estimated residuals from equations [3.4] and [3.5] are stationary: in both the cases, the null hypothesis of a unit-root can be rejected, meaning that there is evidence of a cointegration relationship between the series $\ln(GDP)$ and $\ln(EPC)$.

Causality tests

Given the results from cointegration test, the causality relationship between GDP per capita and electric power consumption per capita should be tested through the implementation of an ECM. Before proceeding with it, the standard Granger causality test is firstly presented.

Following Granger [09], the concept of "causality" assumes a different meaning with respect to the more common use of the term. The statement "$\ln(EPC)$ Granger causes $\ln(GDP)$" (or *vice versa*), in fact, does not imply that $\ln(GDP)$ ($\ln(EPC)$) is the effect or the result of $\ln(EPC)$ ($\ln(GDP)$), but represents how much of the current $\ln(GDP)$ ($\ln(EPC)$) can be explained by the past values of $\ln(GDP)$ ($\ln(EPC)$) and whether adding lagged values of $\ln(EPC)$ ($\ln(GDP)$) can improve the explanation. For this reason, the causality relationship can be evaluated estimating the following two regressions:

$$\Delta \ln(GDP)_t = \alpha_1 + \sum_{i=1}^{m} \gamma_{1i} \Delta \ln(GDP)_{t-1} + \sum_{i=1}^{m} \beta_{1i} \Delta \ln(ECP)_{t-1} + \varepsilon_{1t} \qquad [3.6]$$

$$\Delta \ln(ECP)_t = \alpha_2 + \sum_{i=1}^{m} \gamma_{2i} \Delta \ln(ECP)_{t-1} + \sum_{i=1}^{m} \beta_{2i} \Delta \ln(GDP)_{t-1} + \varepsilon_{2t} \qquad [3.7]$$

where m represents the lag length and should be set equal to the longest time over which one series could reasonable help to predict the other. Following this approach, the null hypothesis that $\ln(EPC)$ does not Granger cause $\ln(GDP)$ in regression [3.6] and that $\ln(GDP)$ does not Granger cause $\ln(EPC)$ in regression [3.7] can be tested through the implementation of a simple F-test for the joint significance of, respectively, the parameters β_{1i} and β_{2i}.

Following Glasure and Lee [08], the equations [3.6] and [3.7] were estimated using four lags of each variable ($m = 4$) which should represent and adequate lag-length over which one series could help to predict the other. The results of Granger's causality test are presented in table 3.3.

Table 3.3. Granger causality test

Regression	F-value
$\Delta\ln(GDP)$ on $\Delta\ln(EPC)$ (Null Hypoyhesis: $\Delta\ln(EPC)$ does not Granger Cause $\Delta\ln(GDP)$)	2.20031 (0.09472)
$\Delta\ln(EPC)$ on $\Delta\ln(GDP)$ (Null Hypoyhesis: $\Delta\ln(GDP)$ does not Granger Cause $\Delta\ln(EPC)$)	1.62712 (0.19517)

Notes: no. of obs. = 37

As shown in table 3.3, only $\ln(GDP)$ (on $\ln(EPC)$) is statistically significant at the 10% level, implying that there is uni-directional causality running from energy consumption to economic growth. This means that the inclusion of past values of $\ln(EPC)$ in the $\ln(GDP)$ equation provides a better explanation of current values of $\ln(GDP)$.

According to the error correction approach, the causality relationship can be evaluated estimating regressions [3.6] and [3.7] after having added up the error correction term represented by the residuals from regressions [3.4] and [3.5] respectively. In other words, the causality can be tested estimating the following regressions:

$$\Delta \ln(GDP)_t = \alpha_1 + \sum_{i=1}^{m} \gamma_{1i} \Delta \ln(GDP)_{t-1} + \sum_{i=1}^{m} \beta_{1i} \Delta \ln(ECP)_{t-1} + \xi_{1i} \mu_{t-1} + \varepsilon_{1t} \qquad [3.8]$$

$$\Delta \ln(ECP)_t = \alpha_2 + \sum_{i=1}^{m} \gamma_{2i} \Delta \ln(ECP)_{t-1} + \sum_{i=1}^{m} \beta_{2i} \Delta \ln(GDP)_{t-1} + \xi_{2i} \eta_{t-1} + \varepsilon_{2t} \qquad [3.9]$$

As pointed out by Engle and Granger [25], the ECM approach offers another possibility to test for causality. In this procedure, $\ln(EPC)$ Granger-causes $\ln(GDP)$ if either the estimated coefficients on lagged values of $\ln(EPC)$ or the estimated coefficient on lagged value of error term from co-integrated regression [3.4] is statistically significant. Similarly, $\ln(GDP)$ causes $\ln(EPC)$ if either the estimated coefficients on lagged values of $\ln(GDP)$ or the estimated coefficient on lagged value of error term from co-integrated regression [3.5] is statistically significant. Therefore, the inclusion of lagged value of error term from co-integrated regression in the ECM permits to evaluate for causality relationship between the series either through the traditional F-test for the joint significance of the parameters β_{1i} and β_{2i} or through the significance of ξ_{1i} and ξ_{2i}.

As before, four lags of each variable ($m = 4$) were used. Table 3.4 reports the results obtained.

Table 3.4. Engle-Granger two-equations error correction model

Regression	F-value	EC_{t-1}
$\Delta\ln(GDP)$ on $\Delta\ln(EPC)$	1.369355 (0.2733)	-0.308577 (0.1332)
$\Delta\ln(EPC)$ on $\Delta\ln(GDP)$	1.776497 (0.1754)	0.114234 (0.5353)

As table 3.4 shows, the findings from ECM are different from the ones resulting from the application of the standard Granger causality test. In this case, in fact, both the F-statistics and the error correction terms are not significant at 5% and 10% level, meaning that no evidence of some causal relationship in Italy results from data.

4. Concluding remarks

This paper aimed to verify the causality linkages existing between energy consumption and economic growth in Italy. Compared to other European countries, Italy's energy sector presents several distinctive characteristics and, therefore, represents an interesting case of study. Specifically, Italy is one of the least energy intensive countries in the world, imports most of its total energy consumed and until the 1990s its internal energy market was exclusively in the hands of few state companies. The causal relationship was investigated employing an ECM approach and the findings were compared to those resulting from the standard Granger causality. Results show that the standard Granger causality test tends to over-estimate causal effects which do not result when the ECM technique is employed. The standard Granger test, in fact, finds evidence of uni-directional relationship running from energy to GDP and this is intuitively reasonable since increased economic growth should ask for enormous consumption of energy. On the opposite, the ECM does not reveal any causality linkage between the variables. These results reverse the recent conclusions of Soytas and Sari [28] which, using coal equivalent as a proxy for energy consumption, find evidence of long run uni-directional causality running from income to energy for

Italy in the period 1950-1992. The different findings may be attributable to several factors, such as the choice of the sample period and the measure of the energy-variable. Nevertheless, it should be stressed that the results of the present study could be augmented in future works to investigate all the potential channels by which economic growth and energy use interact. The econometric methodology could be extended to include other economic factors which may affect both real income and energy consumption (as, for example, exports, capital stock, etc.). This should allow for a complete understanding of the energy-growth interaction mechanisms in Italy.

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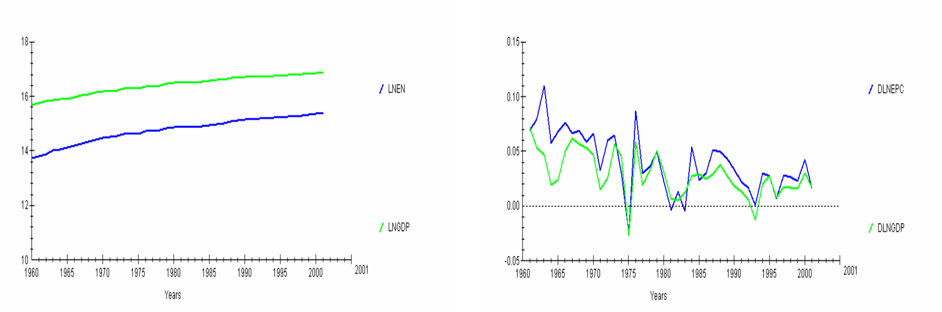
APPENDIX

Table A.1. Summary statistics of variables used

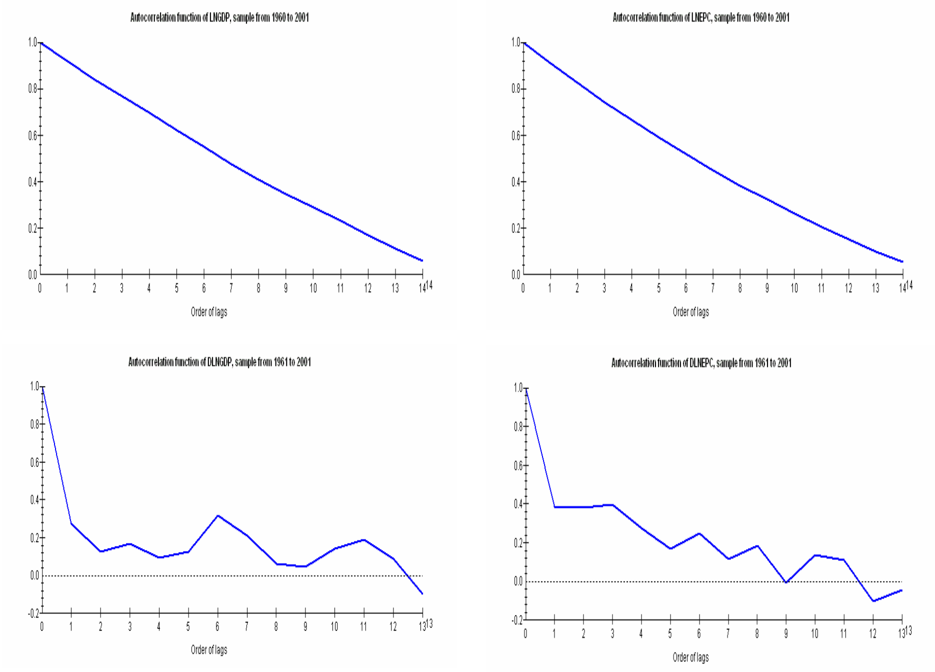
Variable	Description	Max	Min	M	SD	S	K	CV
$\ln(GDP)$	Natural logarithm of GDP per capita (constant 1995 US$)	16.8747	15.7031	16.4163	.33834	-.51759	-.89847	.020610
$\ln(EPC)$	Natural logarithm of electric power consumption (kwh per capita)	15.3868	13.7469	14.7601	.45899	-.59602	-.63970	.031097

Notes: Max = Maximum value; Min = Minimum value; M = Mean; SD = Standard Deviation; S = Skeweness; K = Kurtosis -3; CV = Coefficient of Variation.

*Graph A.1. Time-series of the variables in level and in first differences**



*Graph A.2. Autocorrelation function of the variables in level and first differences**



*Graphs were elaborated using Microfit 4.0 econometric software package.